

Practical protection

Carly Lovejoy looks at a range of underground safety products for workers in hard rock mines, from cap lamps and gas detectors, to refuge chambers and rescue probes

“Following a string of high-profile mining accidents in recent years there has been an increasing awareness of the benefits that personal protection products offer”

As the pressure on mining firms to lower the number of on-site accidents increases, the interest in personal safety products for workers grows.

Accident rates at surface mines are generally lower than at underground operations. The US Mine Safety and Health Administration (MSHA) says that, in 2011, three fatalities occurred at metallic and non-metallic underground mines, while none occurred at their surface counterparts. The figures were similar in 2010.

There are a number of reasons for this: restricted access and a limited supply of fresh air being the main factors. If an incident – such as a vehicle fire – were to occur at an underground mine, it would be much harder to escape the area than at a surface mine.

Underground mines, depending on their depth, are also reliant on ventilation shafts and a network of fans and ducts for a supply of fresh air. If these become disabled in a certain area, or in the event of an incident, such as a fire or a build-up of noxious gases, the fans become unable to pump enough breathable air to the area, then workers will be in grave danger.

Events such as cave-ins and explosions are much less frequent at underground hard-rock mines than at underground coal operations, where the combustible nature of the product increases the occurrence of such incidents. MSHA records show that in 2011, nine fatalities occurred at underground coal mines, and in 2010, 40 fatalities at such mines were recorded.

The US mining industry is among the most highly regulated in the world, and health and safety practices at operations

are exemplary. It is a similar story in other established mining markets, such as Europe, South Africa and Australia, although standards and accident statistics vary greatly in developing markets.

Following a string of high-profile mining accidents in recent years – including San Jose, Chile, in 2010; Pike River mine, New Zealand, in 2010; and a high number of accidents at Chinese mines – there has been an increasing awareness of the benefits that personal protection products offer.

Items such as cap lamps, tracking devices, gas monitors, harnesses, mine refuges, and self-contained self-rescue (SCSR) devices can significantly improve miners chances of survival in the event of a disaster. A number of new models have been released recently, with features such as communications devices, RFID tags and ultra-long life batteries as built-in extras.

The following review looks at the latest products from some leading safety-equipment producers.

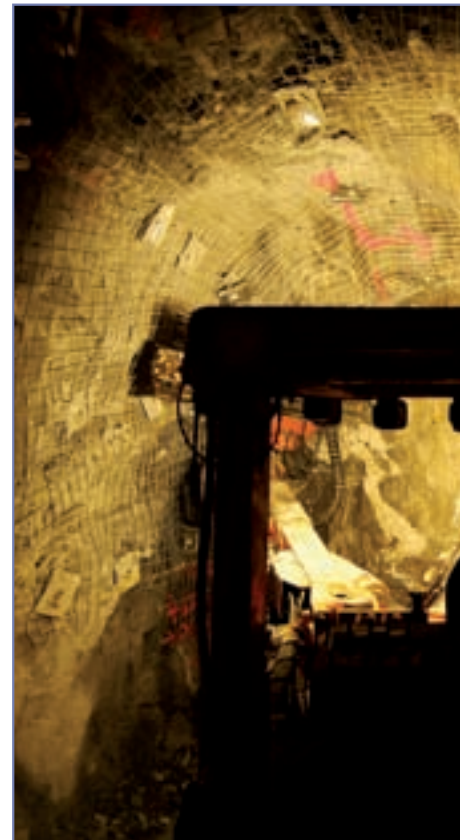
CAP LAMPS

NL Technologies (NLT) is a leading provider of cap lamps. Its range includes the MSHA-approved Eclipse model, which features an LED primary light and lithium-ion batteries. It also has a new charging system that is designed to optimise the life of the batteries. This can be retrofitted to existing Northern Light charging systems.

The Rebel is a portable all-in-one LED cap lamp with three light settings, including a super-high 8,000 Lux beam. Colour filters allow for maximum light and visibility in specific applications. The high-powered lithium-ion battery can be recharged more than 500 times. Rebel offers hands-free operation with five hours

of constant high-beam light, and 20+ hours at medium output. Bulbs last an average of 20,000 hours.

NLT also offers the Polaris cap lamp. This consists of only a headpiece, and is designed for use in underground mining. Polaris uses a high-capacity lithium-ion battery and an LED light source, housed in high-impact dust and water resistant plastic.



NLT is equally focused on hard rock and coal mines. Polaris is the first MSHA-approved cordless cap lamp for use in underground coal mines, and is also safe for use in Group II environments in Europe and Australia. As a result, it was voted winner of the *Mining Magazine* 2011 Underground Soft Rock Award by MM readers.

Heidi Levitt, president of NLT says: “In 2012 we will be releasing our MSHA approved VoIP handset called Ranger. This is a Wi-Fi phone that runs on the NLT Digital network, or on any open standard 802.11b/g Wi-Fi network. This VoIP phone is already Testsafe approved for Australia, and we have been selling it to coal mines and mine rescue organisations in Australia since 2011.

“We will also be releasing our new Genesis cap lamp with tracking tag. Genesis is a slightly bigger brother to our Polaris lamp. It is designed to be tracking tag agnostic, meaning you are not limited to a single vendor of tags. NLT is working with multiple vendors of RFID and Wi-Fi tags so that the customer has a choice of solutions for tracking miners underground, including Aeroscout, Wavetrend, Identec, Ekahau and Digital Innovations.

“This will be the first cordless cap lamp with a multitude of tracking tag offerings, and features similar ergonomics that helped make Polaris such a success.”

NLT's Genesis cap lamp





NLT is working to improve its wireless enabling Mining Network Solutions range. This includes software enhancements that will enable features such as traffic management, collision avoidance and access control functions. It is also enhancing its network monitoring software, which helps mines manage the health and status of the individual components of their mine network, and will continue to develop access points and network products to support the increasing demand for telephony and video underground.

Ms Levitt says: "We have a fantastic product called RT Messenger, which allows a cap lamp to read tracking tags throughout the mine, and to communicate the position of the miner over the Wi-Fi network for highly accurate tracking.

"This means that instead of the miner having to pass a reader to be read, at distances of say 600m, the lamp is actually communicating his position every time he passes an RFID tag, which can be positioned anywhere throughout the mine at distances of 6-600m, for example.

"This lamp is also a two-way text messaging device, and of course, a cap lamp. We are working on enhancements to this product to link it in with developments in traffic management/control and to reduce the overall size of the unit."

Key markets for NLT mine safety products include: North America,

Mexico, Chile, Peru, Brazil, Argentina, Guatemala, Australia, Europe and Japan. The company is looking to expand into Columbia, South Africa, Eastern Europe, Indonesia and Vietnam.

Mine Site Technologies (MST) produces a range of cap lamps and communication technologies, chiefly for the Australian and North American markets, but is expanding, with offices recently opened in Chile and South Africa.

Within six months, MST will also have offices in Germany and Russia, to manage these regions more closely.

MST developed the Integrated Communications Cap Lamp (ICCL) more as a communication and PPE (personal protective equipment) device, than just a cap lamp – although the high-quality LED headpiece adds personal lighting as another function. For many years, MST had fitted communication electronics, such as PED through-the-ear pagers to a range of cap lamps. However, there was always a compromise in size and weight, as well as reliability when dependant on a third-party battery packs.

To gain full control over the total product and guarantee quality and performance, the ICCL was developed. Various versions of the ICCL are available, and they can incorporate any or all of:

- RFID Tags, for tracking miners as they move through the mine;
- PED Emergency warning system receivers, to provide text messages to miners underground regardless of their location; and
- Radios for use with a mine's leaky feeder radio system.

The most recent enhancement is a personal alert device for proximity detection systems. The device will raise an alarm for the miner wearing the lamp when they venture within close proximity of a piece of mobile mining equipment, as well as trigger alerts on board the vehicle approaching the miner.

Denis Kent, of MST, says: "MST's actual role is as a communication solutions provider, so mines choose the model of ICCL to match with the communication infrastructure they have installed.

"Mines typically install our ImPact Digital Network as a core backbone for running applications such as: two-way communications using the VoIP MinePhone; tracking via RFID tags; remote monitoring and control of equipment; managing vehicle performance, and a PED warning system.

"In a number of mines, the same transmission system is also used for

remote, centralised blasting via the BlastPED system."

The ICCL with Personal Alert Device for proximity detection is due for release mid-year. MST also has releases planned this year for new, or enhanced applications to be used with the ImPact network. In particular, the ImPact Communications Appliance (ICA), which is being streamlined to provide reports that meet mine operational and management requirements.

First National Battery (FNB) is South Africa's premier provider of cap lamps and produces the 16 Ah Accumulator and 4 Ah LED Accumulator models. The batteries are the maintenance-free lead acid type, which has proven both durable and safe over some 70 years in mines. The maintenance-free technology was introduced about 30 years ago, and became a standard throughout the company's products.

Tom Cross, of FNB, says: "In 2003 we introduced LEDs in our cap lamps, replacing incandescent bulbs. The lower current drawn by the LED's has enabled us to reduce the capacity of the battery to a quarter and the weight by 60%. The higher light output also created a safer working environment for miners.

"Most South African mines use our lamps. The LED lamp is preferred because of the quality of the light and the lightweight battery."

In 2011, FNB launched a safe battery range for its lamps, in full compliance with the new South African cap-lamp safety standard due to be announced later this year. In 2012, the company will launch an even smaller cap lamp. This will comprise an advanced optic system, powered by a lithium-ion battery. While it will be a lot ▶

"In 2012 we will be releasing our MSHA approved VoIP handset called Ranger"

MST's communications networks allow phones and laptops to be used underground





A Trolex
TX6648 unit

smaller and lighter than the current models, the basic FNB design of ruggedness and durability will remain.

Mr Cross says: "We consider a cap lamp the miner's foremost safety item, and the FNB design has been tested and proven over many decades." He says that in the coming years, LED light efficiency will continue to improve, offering scope for smaller power packs. It will also provide reserve power for supply to advanced safety devices, such as miner tracking and collision avoidance systems.

GAS DETECTION

Trolex supplies gas detection and monitoring equipment, pressure and temperature sensors, flow sensors, level sensors, heavy-duty Ex connectors, vibration sensors, and a range of control and display equipment to offer mines a full gas detection, machine condition monitoring and safety systems package.

For example, its Sentro 8 multi-use sensor station brings together an array of hazardous-area technologies. These are served by universal data communications architecture, making it straightforward to network sensor stations to a master computer and expand the system if required at a later date.

Each Sentro 8 can simultaneously monitor the concentration of up to eight gases, together with ambient temperature, ventilation, air velocity or any choice of remote connected sensors.

A spokesperson for Trolex says: "The flexibility of the Sentro 8 is a key benefit. It can serve as a machine conditioning monitoring station, ventilation fan monitoring or conditioning monitoring of pumps and motors."

Trolex also supplies the TX6648/9 UPS (uninterruptible power supplies) that maintain its systems, including the Commander TX2100 series controller and data communication products, as well as the Sentro controller stations, plus all of the associated sensors.

Trolex products have become well established in Russia and former Soviet Union states. The company counts Norilsk Nickel and diamond miner Alrosa among its customer base.

"We already have a broad international base and are further enhancing our strategic focus to ensure truly global coverage," says the spokesperson. "Regional sales leads have been appointed for all our key markets, including China, Russia, Australia, South Africa, South America and the US. In addition, we are focussing on developing our mine monitoring systems."

Trolex also has a new monitoring system for mine refuge chambers. This is ATEX approved and will soon be MA approved. "Many customers have been asking us to develop a fire and smoke detection system for this environment, and that is also in development," the spokesperson adds. "We are focussing on development of our wireless technology and control systems. We already offer mine monitoring systems, but are investing more in research to bring the best technologies to the market in terms of mine-wide solutions. There will also be further development of products for refuge chambers."



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Strata Worldwide is a leading supplier of mine refuge chambers, both in the US and abroad. Offering customized designs and features, Strata chambers can be built for any application.

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Ryan Fielden
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Tony Farrugia
+61 (0) 3979 8853
tfarrugia@strataproducs.com.au

STRATA WORLDWIDE - SOUTH AFRICA
Jonathan Metcalf
+27 (0)17 632 1257
jmetcalf@strata-safety.co.za

strataworldwide.com

General Monitors has released the PA4000 Photoacoustic Infrared Gas Monitor, which provides precise, high-performance gas monitoring while eliminating interference from water vapours. The company says it offers a reliable, low-maintenance solution in situations where contaminants or interference preclude use of other measurement techniques.

The PA4000 uses an advanced photo acoustic, infrared sensor to monitor a variety of gases including hydrocarbons, solvents, alcohols, CO₂, CO and other dangerous gases. It is stable and highly selective to the gas of interest and can operate for months with virtually no drift. It also eliminates cross-sensitivity to water vapour using a proprietary sensing technique that determines the amount of water vapour in the sample and subtracts it from the gas reading.

The PA4000 indicates gas concentrations and triggers an alarm where necessary. The direct reading display shows the actual gas value, as well as any alarms and diagnostic messages. The unit can be configured to monitor up to eight remote areas, with standard features including a vacuum fluorescent display, audio alarm and four relays. It can be housed in general purpose, explosion-proof or rack-mount enclosures.

US-based Industrial Scientific has made its Ventis LS multi-gas detector available as part of the Accenture Life Safety Solution. The system uses Wi-Fi and location-based technologies to remotely monitor those working in potentially hazardous environments, including underground mine sites.

The Ventis LS can detect up to four gases at a time, including H₂S, O₂, LEL, CO, SO₂ and NO₂. In potentially hazardous conditions, the instrument alerts users through audible, visual and vibrating alarms. The gas-level information is then transmitted over Cisco's Unified Wireless Network using the gas detector's integrated Wi-Fi Tag from AeroScout. The operator can quickly locate the employee in danger and organise a response. A separate alert would be sent to the control room if lack of motion is detected, or if the individual activates the panic button.

MINE RESCUE AND REFUGES

Canadian-based Newtrax provides the MineTrax Post-Accident Network Probe (PANP) for mine rescue situations. Following an underground mine cave-in, fire, explosion or flood it is often difficult to determine the location of miners that are still underground. Rescue teams may attempt to contact miners by drilling bore holes and dropping down a telecommunication line, but unless the

workers are in the immediate vicinity these attempts can prove futile.

Underground communication networks based on a wired backbone will not work in many post-accident scenarios because cables will have been cut. Even when tentatively redundant closed-loop wired networks backbones are initially deployed, the operational complexity of continuously extending the network as the mine expands can lead to the use of open-ended cable extensions for coverage in many active areas of the mine. Since fixing broken cables underground from the surface via a borehole is not realistic, an alternative solution is required for reliable and cost-effective post-accident backhaul communications to surface.

Newtrax CEO and founder, Alexandre Cervinka, says: "Through-the-earth (TTE) technology has its merits as a post-accident backhaul link to surface technology, and MineTrax networks can use it as an alternative to leaky feeder, fibre optic or twisted-pair for backhaul links to surface.

"Newtrax encourages the simultaneous use of several different types of backhaul links to maximise the probability of at least one link surviving the accident. Since



the MineTrax network is self-healing, it will automatically re-organise itself to send/receive data from the surface via any backhaul link available."

The PANP is an alternative to TTE technologies and provides post-accident two-way backhaul communications from an isolated area underground to surface. PANP is simpler and cheaper than TTE. It supports a higher bandwidth and has no maximum depth limitation. Via ventilation shafts or a 5cm borehole, mine rescue teams can drop down the PANP via a cable and let the MineTrax self-healing, battery-powered wireless network ▶

A MineTrax node from Newtrax. The system allows post-accident communications

"A good example of how our technologies can be applied comes from Mexican gold and silver producer Fresnillo. It has purchased all the solutions in the MineTrax portfolio"

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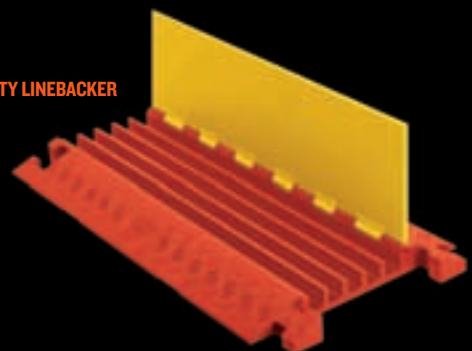
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“Rescue team comms still to this day prove to be difficult, unless the mine is equipped with a comms system that has survived the disaster”

► reconfigure itself to use this “new” backhaul link to surface.

Several PANPs can also be installed pre-emptively (instead of reactively) close to active areas to create additional permanent backhaul links to surface, effectively increasing the probability that at least one link will survive in the event of an accident. If at least one link survives in the post-accident isolated area, the system will not experience any downtime.

The PANP is patent pending in all major mining markets around the world.

Newtrax also sells MineTrax-enabled gas detectors, which are manufactured by CONSPEC Controls. The company produces a full line of gas detectors for hard-rock mines including: CO, CO₂, SO₂ and H₂S. Newtrax supplies CONSPEC with ultra-low power MineTrax mesh routing/RFID tag reading modules that are built into the units.

Mr Cervinka says: “What’s unique about this new generation of battery-powered wireless gas detectors is that there are three functionalities in one self-contained autonomous device: a mesh network node repeater, an RFID tag reader and a gas detector.”

He adds: “A good example of how our technologies can be applied comes from Mexican gold and silver producer Fresnillo. It has purchased all the solutions in the MineTrax portfolio.”

MM has seen a copy of a letter of support from Fresnillo CIO Baldomero Gutierrez, which nominated Newtrax for the 2012 Engineers Canada Innovation prize, that says: “In 2011 we started to implement MineTrax at our La Cienega mine and the first phase of the project has been a success. We intend to standardise the use of MineTrax in all of our mines and are excited by all the potential safety, productivity and environmental benefits.

“MineTrax is a truly breakthrough technology since to my knowledge it is the only mine safety system with wireless network infrastructure capable of lasting several years on a few small batteries. All other vendors have at best autonomy of a few days. For us, this translates into an unprecedented level of simplicity: we don’t need to install any wires for power or communications.”

In 2011, Newtrax released a new MineTrax system to monitor ground stability in real-time based on SMART

cable extensometers which has already been deployed at more than ten mine sites, and in February this year, the company launched a MineTrax-enabled MDT geotechnical sensor, the Sloughmeter. Another type of geotechnical sensor, based on vibrating wires, will also be released in June-July 2012.

For R&D in the coming year, Newtrax intends to focus on integrating more types of sensors into its product range and adding vehicle dispatch systems. Mr Cervinka says: “MineTrax is the ideal tracking and networking platform underground because of its pervasive and persistent nature. Our customers are always asking us to integrate new applications, including vehicle dispatch systems.”

He adds: “Our customers are currently in Canada, the US, Mexico, Chile, Argentina, Finland and Australia. We have several projects in the pipeline in Peru, Russia and South Africa.”

Strata Worldwide provides refuge chambers for hard-rock mining. Chambers provide breathable air and a safe environment for personnel to take cover in the event of an emergency that prevents their escape from the mine. They can be ►

Expert opinion

Independent mine rescue consultant Brian Robinson (pictured) gives his thoughts on the current state of mine rescue technology

Success stories in mine accidents, such as Quecreek (2002) and San Jose (Chile 2010) always give a good feeling to rescue workers and miners alike. However, they are few and far between. Western mine disasters have been big news in the past decade, just the thought of the mine names – Darby, Sago, Pikev River, Alma, Upper Big Branch or Gleision – is enough to raise the hairs on your neck.

In these latter cases, miners have died as a result of fire, explosion and flooding, but importantly, in all but one case (Pike River), rescue teams had to enter extremely hostile environments wearing breathing apparatus because of hazardous atmospheric conditions, much the same as rescue teams would have 30 or even 60 years ago.

So what has changed in the mine escape and mine rescue world?

To begin, SCSRs are coming into a new generation, this will give mine workers a better chance to get to the next technical advancement, the refuge chamber. Many designs and manufacturers exist, either inflatable or hard-type shelters give complete and self contained protection for miners for 96 hours or so, a major feat in itself.

Although we still rely on rescue teams walking into these environments to attempt search and



rescue measures, the way in which we are able to protect trapped miners and rescue team members with equipment has improved greatly.

When we send teams in, the modern enhancements in breathing apparatus include cooling, and the use of “positive pressure” in the self-contained breathing apparatus (SCBA), all giving increased safety and comfort for the wearer. The Drager BG4 four-hour oxygen unit, although now some 19 years old, is the leader, relied upon by rescue teams worldwide.

Through research it has been shown that team members benefit from being able to take on cold “isotonic” drinks, preventing dehydration and over-heating. Most major manufacturers

now offer masks with drinking facilities built in, proving safe and effective in operation.

Hand the team a good thermal imaging camera to “see” through the smoke and travel time is boosted, thus gaining distance quicker, picking up casualties and giving them a better chance of survival. Team safety is also better, as rescuers can see obstacles, road junctions, heat and casualties.

Rescue team communications still to this day prove to be difficult, unless the mine is equipped with a communications system that has survived the disaster. Having to lay cable systems that are vulnerable to damage, and are sometimes unreliable, is difficult and time consuming. This is an area that would benefit from good technology being brought in, be it hi-or low-tech, as long as it works.

A statement from the enquiry report following the Sago explosion of 2006 speaks volumes; “There would have been no disaster if mine rescue teams had been sent into the mine sooner and allowed to advance, without being required to systematically assess post explosion conditions throughout the mine on the way in. But there were delays in organising the rescue.

“That approach, whatever its merits, greatly diminished the chances of winning the race against deadly carbon monoxide.”

Give rescue teams better training, better equipment, and give them a chance to do their work, and more success reports will hopefully follow.

► crucial to ensure workers' survival.

Strata provides traditional steel walk-in refuges. These are electrically powered with battery back-up and active scrubbers that use fans to move the air through soda lime chemicals for CO₂ removal.

Flow meters control the air flow, which is set according to the number of occupants. They are set for 48h use as standard, but can be scaled up or down according to user's needs. The refuges also include: an airlock entrance with an optional purge air system, cooling system and dehumidifier, LED lights, escape hatch and food and water. Sizes range from 8- to 30 man units.

The company says that its refuge chambers are compact and relatively lightweight. They are designed for ease of movement in confined areas, and optional wheels and hitch packages are available on all models. Gas monitoring systems to monitor air conditions inside and outside the chamber are also available.

Strata has sold chambers in the US, Australia, South Africa, Canada, China, Norway, Portugal, Hong Kong, Mexico, Peru, Chile, Brazil, Argentina, Nicaragua, Zimbabwe and the UK. Its most popular models for hard-rock mines are 12- and 30-man units.

A spokesperson for Strata says: "Strata is heavily involved in further expanding its electronic safety and communications technologies. The company offers a proprietary wireless data communications and tracking system that meets MSHA's PPL requirements – CommTrac. Additionally, with CommTrac's tracking capabilities mines can track equipment and machinery underground.

"Strata also recently introduced intrinsically safe Wi-Fi with digital voice over IP (VoIP) communications. It is planning to offer IS tablets and PDA's for Internet access via Wi-Fi underground."



TRIAGE

In December 2011, Honeywell launched its Safe Triage technology system, which was developed in conjunction with Safe Patient Systems. Safe Triage helps emergency responders provide fast and accurate on-scene support and diagnosis of injured workers in the event of an accident.

Safe Triage Pro is a fully-automated, hand-held triage device designed by clinicians for use by paramedics. It enables fast delivery of patient information to receiving medical facilities to improve clinical governance and patient safety. The system is designed to support the treatment of mass casualties, as well as day-to-day emergency response incidents.

Honeywell is also distributing a second "Lite" version aimed at non-medically trained users. Safe Triage Lite integrates communication technology to enable remote medical diagnosis and support to those working in challenging and remote locations such as mine sites. It also contains a comprehensive medical and drugs database, giving non-medically trained users fast access and easy-to-follow expert medical assistance and guidelines.

The system was originally developed for use by air ambulances. Information on the patient is input into a ruggedized, hand-held computer that uses satellite and GPS technology to relay it to the receiving medical unit. It has a front- and backwards-facing camera, so images can be taken of the injury and the scene. Videos can also be captured and transmitted to the mine first-aid facility, allowing medics to make decisions on whether the worker needs to be evacuated or treated in the field. The kit also includes ultrasound and defibrillator tools that can be connected to the system using Bluetooth wireless technology.

Mark Doorbar, chief executive of Safe Patient Systems, says: "It's about having real-time decision making support for



people who may not be medically qualified, or indeed they may be paramedics that need that little extra help.

"The system works with a very simple touch screen; you can have your standard operating protocols. This might be how to deal with certain health and safety issues, or it might be how to deal with a case of severe bleeding. So, the information is readily available for the individual at the time that there is an injury.

"The other advantage is that you can actually store the records of the workforce. If someone is injured in a mine, when you enter their name into the system it will bring up their medical records, next of kin, pre-existing allergies etc."

The patients vital signs can also be monitored remotely, for example, if someone has been injured in a rock fall, they can be monitored safely from a distance of 10m, so the rescuer is not put at risk while waiting for help.

Mr Doorbar says that when working underground, the information can be stored and relayed to the nearest medical facility by satellite once the rescuer emerges, or the system can link into the mine's underground communications.

"Say you have a mining disaster where there are multiple cases and you need to decide who to evacuate first," he explains. "There is a rapid response profile that asks simple yes or no questions, so you can quickly assess who needs medical attention first. The information is then sent on a scorecard that shows the number of minor and critically injured persons, dead, trapped, need immediate evacuation and so forth, to the control centre from which the appropriate resources can be deployed." ♥

Above: Safe Triage Lite integrates communication technology to enable remote medical diagnosis and support to those working in mine sites

Left: a hand-held computer is at the heart of Honeywell's Safe Triage System

"If someone has been injured in a rock fall, they can be monitored safely from a distance of 10m, so the rescuer is not put at risk while waiting for help"